



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

July 11, 2003

Fire Fighter Suffers Sudden Cardiac Death During a Medical Emergency Response - California

SUMMARY

On May 22, 2002, a 28-year-old male first-year fire fighter responded to a medical emergency call at 0318 hours. The fire fighter and his crew found the patient in full cardiac arrest and initiated advanced life support (ALS) procedures, including cardiopulmonary resuscitation (CPR). After working on the patient for approximately 30 minutes, the patient was carried down some stairs and loaded into the ambulance for transport. Approximately one minute after the ambulance departed, the fire fighter collapsed. One of the crew members witnessed his collapse and initially believed he was joking around, but quickly realized he was unresponsive with agonal (gaspings) respirations. A second ambulance was called as ALS procedures and CPR were initiated. Despite treatment on-scene for 32 minutes, during transport for 12 minutes, and in the hospital for 23 minutes, the victim died. The amended death certificate and the autopsy report completed by the County Coroner's Office listed "Complication of Hypertrophic Cardiomyopathy" as the immediate cause of death.

A number of agencies have developed preventive measures to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity. This strategy has not been evaluated by NIOSH, but represents research presented in the literature, consensus votes of Technical Committees of the National Fire Protection Association (NFPA), or labor/management groups within the fire service. Most, if not all, of these measures are already being

followed or are scheduled to be in place by this Fire Department (FD). Therefore, it is unlikely the FD could have prevented this fire fighter's untimely death. Nonetheless, potentially relevant safety issues applicable to this FD include:

- *Consider slightly modifying the preplacement, annual, and periodic medical evaluations to be consistent with NFPA 1582.*
- *Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.*
- *Enhance the FD's current wellness/fitness program by implementing the proposed program.*

INTRODUCTION & METHODS

On May 22, 2002, a 28-year-old male fire fighter collapsed during an emergency medical response.

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at

www.cdc.gov/niosh/firehome.html
or call toll free 1-800-35-NIOSH



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Despite treatment by FD paramedics and emergency medical technicians (EMTs) on the scene, ambulance paramedics, and staff from the hospital emergency department, the victim died. NIOSH was notified of this fatality in May 2002, by the United States Fire Administration. In March, 2003, NIOSH contacted the affected FD to initiate the investigation. On March 31, 2003, an occupational physician from the NIOSH Fire Fighter Fatality Team traveled to California to conduct an onsite investigation of the incident.

During the investigation NIOSH personnel met and/or interviewed the:

- FD Chief, Deputy Chief, and Battalion Chief
- Local Fire Fighter Union President
- Crew members on-duty with the victim
- Victim's father
- Contractor administering the Medical Evaluation Program.

During the site-visit NIOSH personnel reviewed:

- Dispatch logs
- FD investigative report of the fatality
- Hospital Emergency Department (ED) resuscitation records
- Death certificate
- Autopsy report
- FD training records of the victim
- FD pre-employment/pre-placement medical evaluation
- FD annual report for 2002

INVESTIGATIVE RESULTS

Incident. On May 22, 2002, at 0318 hours dispatch received a call for a man having a seizure at his town home. Engine Company E-3456 [composed of a Captain, an Engineer, and a Fire Fighter (the deceased)] was dispatched at 0319 hours, and arrived on the scene at 0328 hours. Despite all fire fighters being trained as EMTs, including one

paramedic for each company, County protocol requires that a private ambulance service respond to all emergency medical calls. The private ambulance company was dispatched at 0319 hours and arrived on the scene at approximately 0329 hours.

E-3456 was first to arrive on the scene and found an unresponsive, very obese 63-year-old man. Initial vital signs revealed the lack of respirations and no pulse. The patient was repositioned by E-3456 as they prepared to administer CPR and ALS procedures. To assist with carrying the patient, they also requested dispatch to assign T-3476 to the call. T-3476 arrived on the scene at 0332 hours. After placing a cardiac monitor on the patient, giving numerous defibrillations, placing a breathing tube into the patient's lungs (intubation), and giving numerous intravenous (IV) medications, the patient was ready to be carried down the stairs into the waiting ambulance.

A canvas tarp was used to carry the patient down the stairs, and four fire fighters each held a corner of the tarp. Shortly after starting down the stairs, the deceased fire fighter, without warning, let go of his corner. The other fire fighters considered this unusual and, in retrospect, felt this was the first hint that he was not feeling well. The patient was loaded into the back of the ambulance and the deceased fire fighter assisted the ambulance driver by guiding his departure from the parking lot at 0405 hours.

As the ambulance departed, one of the fire fighters started back toward the townhouse to gather their equipment when she noticed the deceased fire fighter lying alongside a driveway. Initially, thinking he was joking around, she approached him to get him up, but she quickly noticed his agonal respirations. She yelled for crew members to call an ambulance for a fire fighter down. A second ambulance was dispatched to the scene at 0407 hours and arrived at 0423 hours.

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The other fire fighters (EMTs and paramedics) on the scene grabbed the medical equipment from T-3476, while the initial medical evaluation took place. The initial evaluation found the fire fighter unresponsive with a pulse in his extremities. Approximately thirty seconds later the medical equipment arrived and an oral airway was placed, while the cardiac monitor was hooked up and an IV line placed. The cardiac monitor showed the rapid deterioration (over about 15 seconds) of his heart rate from a normal sinus rhythm, to bradycardia (a slow heart beat) to pulseless electrical activity, to asystole (no heart beat). A breathing tube was placed into his lungs (intubation) with appropriate confirmatory tests by primary (clinical breath sounds) and secondary (end-tidal carbon dioxide monitor and bulb test) methods. CPR continued and IV medications were administered until the ambulance arrived at approximately 0423 hours. The ambulance crew reassessed the fire fighter and continued appropriate ALS procedures. At 0438 hours they placed the fire fighter in the back of the ambulance for transport to the hospital and arrived at the emergency department at 0450 hours.

In the hospital ED additional IV medications were administered followed by an attempt to restart the fire fighter's heart by a pacemaker. This was unsuccessful and the fire fighter's heart rhythm remained in asystole (no heart beat). CPR continued along with additional IV medications and defibrillations (shocks). CPR and ALS continued for a total of 22 minutes in the hospital ED. At 0412 hours, the fire fighter was pronounced dead and resuscitation measures were discontinued.

E-3456 had two calls during their shift: a motor vehicle accident at 1331 hours and a fire alarm at an apartment building at 1930 hours. During the second call, E-3456 was cancelled en-route. During the evening, the deceased fire fighter exercised as part of the FD's mandatory physical training program.

He did strength conditioning exercises for approximately one hour before retiring for the evening at 2330 hours. At no point during his shift or during his exercising did he complain of cardiac symptoms to his crew members.

Medical Findings. A forensic pathologist from the County Coroner's Office conducted an autopsy. Pertinent findings included:

- An enlarged heart weighing 565 grams (normal less than 400 grams)
- Thickened left ventricle of 2.0 centimeters (cm) in diameter (normal <1.3)
- Thickened right ventricle of 1.0 centimeters (cm) in diameter (normal <0.8)
- Minimal atherosclerosis in the coronary arteries
- A surgical patch and scar at the apex of the heart's left ventricle consistent with a well healed surgical repair of an old knife wound to the chest
- Bilateral fibrous pleural adhesions and pericardial sac adhesions also consistent with his old knife wound to the chest
- No evidence of a blood clot (embolus) in the pulmonary arteries
- A negative drug screen of illicit drugs (e.g. cocaine)
- Histology (microscopic) examination of the heart tissue was not performed

"Complications of Hypertrophic Cardiomyopathy" was the cause of death reported on the autopsy report and the amended death certificate. As mentioned earlier, the fire fighter sustained a knife wound to the chest and heart in 1995. This wound was repaired surgically without any residual problems. According to his family and his co-workers, the deceased fire fighter never complained of any symptoms suggestive of cardiac problems (e.g., chest pain, shortness of breath, dizziness, palpitations, etc.). In addition there was no family history of sudden cardiac death.



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DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the Fire Fighter's death, the FD consisted of approximately 243 Uniformed Fire Fighters / Fire Officers, and approximate 50 Volunteers serving a population of 234,000 residents, in a geographic area of 461 square miles with 16 fire stations. Two of these stations are staffed with engine crews of four fire fighters. The other 14 fire stations are staffed by crews of three fire fighters per apparatus.

Fire fighters work a 24-hour shift (Day 1), followed by 24 hours off duty (Day 2). This sequence is repeated on Days 3-4 and Days 5-6. Day 7-9 are days off prior to the sequence repeating (this averages to a 56-hour work week). Shifts begin at 8:00 a.m.. In fiscal year 2001-2002, the FD responded to more than 19,000 emergency calls. After serving for 18 months as volunteer member of the fire department, in July of 2001, the victim was hired as a career fire fighter in a two-year probationary status.

Preplacement Evaluations. Since February of 2001, fire fighter candidates are required to complete a physical ability test at the time of their application. The test used by this FD is the "Candidate Physical Ability Test" developed jointly by the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC).¹ All qualified Candidates passing this test are placed on a hiring list. As positions in the FD become available, applicants then undergo a preplacement medical evaluation performed by a contractor hired by the County. In 2002 the contract was awarded to a new provider. The current contract with the new provider has the following components of the preplacement evaluation for all applicants:

- Complete medical history and questionnaire
- Height, weight, and vital signs
- Physical examination

- Vision test (excludes peripheral vision testing)
- Urinalysis (dipstick)
- Audiogram
- Spirometry (lung function tests)
- Blood tests: Complete blood count, chemistry panel (SMA 6) which includes a serum glucose measurement
- Chest X-ray (one view - PA)
- Resting electrocardiogram (EKG)
- Skin test for tuberculosis (PPD)
- Immunizations administered if proof of vaccination cannot be provided [hepatitis B, measles, mumps, & rubella (MMR), and varicella.]

The contractor who administers this screening program also performs the respirator fit testing and medical clearance to: 1) wear a respirator, and 2) perform fire fighting duties. Candidates for the volunteer fire fighter positions are also given a preplacement medical evaluation consisting of items #1-7 and 11, listed above.

Periodic Evaluations. Since 2002, the new medical contractor is also providing the annual medical evaluations required for **all** career fire fighters. This evaluation consists of a medical and exposure history, height, weight, pulse, blood pressure, a physical examination, vision test, dipstick urinalysis, and, if appropriate, immunization boosters. A more comprehensive medical examination is performed according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year). This examination consists of:

- Complete medical history and questionnaire
- Height, weight, and vital signs
- Physical examination
- Vision test (excludes peripheral vision testing)
- Urinalysis (dipstick)
- Audiogram
- Spirometry (lung function tests)

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- Blood tests: Complete blood count, chemistry panel (SMA 6), a serum glucose, a liver and lipid profile, and a test for exposure to pesticides (plasma and RBC cholinesterase tests)
- Resting EKG

The deceased fire fighter's last medical evaluation was performed in November, 2000 as part of the FD's periodic medical evaluation. This consisted of items 1-5 listed above and, item number. All of the test results were within normal limits, and he was cleared for full fire fighting duty without restrictions.

Medical Clearance, and Fitness/Wellness Programs.

If a fire fighter is injured at work, he/she must be evaluated and cleared for "return-to-work" either by their contract physician or their private physician. A fire fighter who misses work for one or more days because of an illness (work-related or not), must also be cleared for "return-to-work," typically by their private physician.

All fire houses have exercise (strength and aerobic) equipment purchased by the FD. The FD has a mandatory physical training program which involves 60 to 90 minutes of strength and aerobic exercises. This program is integrated with the above mentioned annual medical evaluations, respirator fit testing, and immunizations. In the fall of 2003, the FD is planning to enhance its program by adding a individualized wellness/fitness profiles for FD employees. These profiles will not only contain health appraisal and risk information, but also customize any health recommendations. This program is similar in content to the IAFF/IAFC wellness/fitness initiative.²

DISCUSSION

On autopsy the deceased fire fighter was also found to have hypertrophic cardiomyopathy (HCM). This diagnosis was made by the large heart (565 grams) and thickened left and right heart ventricles, 2.0 and

1.0 centimeters, respectively. No microscopic tests were conducted, however typical cardiac cellular changes include focal hypertrophy with irregular muscle bundles.³

HCM is a relatively rare heart condition, effecting approximately 0.2% of the population.⁴ The majority of patients are asymptomatic, however, sudden cardiac death is often its first clinical manifestation, particularly among patients less than 30 years of age.⁵ Risk factors for sudden death among HCM patients include young age (<30 years old) at diagnosis, a family history of HCM with sudden death, an abnormal blood pressure response to exercise, severe symptoms, non-sustained ventricular tachycardia, marked hypertrophy, marked left atrial dilatation, and genetic abnormalities associated with increased prevalence of a sudden death.⁴⁻⁶

Approximately half of the HCM cases are transmitted genetically, typically in an autosomal dominant trait with disease loci on at least eight different chromosomes.⁷ Unfortunately, genetic testing is not routinely available and remains largely a research tool. The causes of HCM in the other half of patients is unknown.⁵ The victim's father has been made aware of the familial distribution (inherited pattern) of this condition, but since the victim had no siblings or children, subsequent medical screening of relatives is not warranted.

Could a more comprehensive FD preplacement medical evaluation have identified this condition? As mentioned earlier, the contractor at the time of this fire fighters preplacement medical evaluation did not include a resting EKG. However, the 2000 Edition of NFPA 1582 (*Medical Requirements for Fire Fighters and Information for Fire Department Physicians*), does not recommend a routine preplacement EKG unless specifically indicated.⁸ If, for some reason a resting EKG was done, it might have detected his enlarged heart. However, in an

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active, healthy, asymptomatic 28 year old man, this finding probably would have been attributed to an “athletic heart” and not investigated further.

Had the victim’s HCM been identified during the FD’s preplacement evaluation, would he have been denied employment as a fire fighter? HCM is not specifically addressed in NFPA 1582. However, it would most likely be considered a Category B Medical Condition, defined as “a medical condition that, based on its severity or degree, **could** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others.”

Had the victim’s HCM been identified, would this have prevented his death? Although a variety of symptoms and medical tests can provide prognostic information, patients at greatest risk of sudden death or in need of anti-arrhythmic therapy are hard to identify. Given the victim’s few above mentioned risk factors for sudden death, the low degree of efficacy of anti-arrhythmic agents and their numerous side effects, and the lack of symptoms in this fire fighter, it is unlikely that a diagnosis would have led to treatment. Therefore, it is unclear if his tragic sudden death would have been prevented even if his condition was identified.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.⁹ Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.¹⁰⁻¹² Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹³⁻¹⁷

Among other things, NFPA 1582 was developed to reduce the risk of sudden cardiac arrest and heart attacks among fire fighters. NFPA 1582 recommends, not as a part of the requirements but for informational purposes only, that all fire fighters above the age of 40 have an Exercise Stress Test (EST) to screen for obstructive coronary artery disease (CAD). Unfortunately, EST have problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of CAD), particularly in young men, and women.^{18,19} This has led other expert groups to not recommend EST for asymptomatic individuals without risk factors for CAD.²⁰⁻²²

When asymptomatic individuals have risk factors for CAD, recommendations for EST vary by organization. NFPA 1582 recommends biannual EST for fire fighters with CAD risk factors beginning at age 35.⁸ For medical certification for the commercial drivers license issued by the U. S. Department of Transportation, they recommend EST for drivers over the age of 45 with more than two CAD risk factors.²⁰ The American College of Cardiology/American Heart Association do not think that “there is evidence and/or general agreement that [EST] is useful and effective” in asymptomatic persons without known CAD, but they identify four groups of such persons for which “there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy” of EST. In these groups, EST’s “usefulness/efficacy is less well established by evidence/opinion” (as opposed to the “weight of evidence/opinion [being] in favor of usefulness/efficacy”).²¹

- Group 1: Persons with multiple risk factors. Five risk factors for CAD are defined: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic blood pressure greater than 140 mm Hg or diastolic pressure greater than 90 mm Hg), smoking,

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diabetes, and family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

- Group 2: Men over the age of 40 and women over the age of 50 (especially if sedentary) who plan to start vigorous exercise.
- Group 3: Men over the age of 40 and women over the age of 50 who are at high risk for CAD due to other diseases (e.g., chronic renal failure).
- Group 4: Men over the age of 40 and women over the age of 50 who are involved in occupations in which impairment might impact public safety.

Finally, the U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).²² The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population but notes that “screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety.”²²

None of these expert organizations would have recommended an EST for the deceased fire fighter. Further, after reviewing all the above organization’s recommendations regarding EST, this FD has decided not to include EST as part of its periodic medical examination. In its place is a plan to enhance its existing fitness/wellness program.

RECOMMENDATIONS

A number of agencies have developed preventive measures to reduce the risk of on-the-job heart

attacks and sudden cardiac arrest among fire fighters. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity. This strategy has not been evaluated by NIOSH, but represents research presented in the literature, consensus votes of Technical Committees of the NFPA, or labor/management groups within the fire service. Most of these measures are already being followed, or are scheduled to be in place by the end of 2003. Therefore, it is unlikely the Fire Department could have prevented this fire fighter’s untimely death. Nonetheless, potentially relevant issues applicable to this FD include:

Recommendation #1: Consider slightly modifying the preplacement, annual, and periodic medical evaluations to be consistent with NFPA 1582.

The FD has an excellent medical screening program based on NFPA 1582. However, there are a few minor discrepancies. Extra components currently being conducted by the FD, but not found in the 2000 Edition of NFPA 1582 include: 1) the physical examination and urine dipstick test in the annual medical evaluation, and 2) some laboratory tests in the comprehensive periodic medical examination. These extra laboratory tests include a) the hemocult test for occult blood, b) cholinesterase levels, c) hepatitis-B titers, and d) a resting EKG.

The only component not being followed by the FD is the EST. As mentioned in the discussion section of this report, the FD has fully considered the pros and cons of the EST and made an informed decision not to include this test.

The FD should be aware that in the summer of 2003 the NFPA will be voting to accept revisions to NFPA 1582. If passed, the revisions will modify the

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components of the preplacement and periodic physical examinations.

Recommendation #2: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.

Physicians providing input regarding medical clearance for fire fighting duties should be knowledgeable about the physical demands of fire fighting and familiar with the consensus guidelines published by NFPA 1582. The return-to-work decision requires knowledge not only of the employee's medical condition, but also of the employee's job duties. Although the FD contractor is aware of essential job tasks and NFPA 1582, many private physicians are not. Therefore, NIOSH recommends that the FD not automatically accept the opinion of the employee's private physician regarding return to work and consider having all return-to-work clearances reviewed by the FD's contractor. Thus, the final decision regarding medical clearance for return to work lies with the FD with input from many sources including the employee's private physician.

Recommendation #3: Enhance the FD's current wellness/fitness program by implementing the proposed program.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, and NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, require a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.^{23,24} In 1997, the IAFF and the IAFC published a comprehensive *Fire Service Joint Labor Management Wellness/Fitness Initiative* to maintain physical and mental capabilities of fire

fighters, prevent health problems, and enhance their overall well-being.² Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.²⁵⁻²⁷ A similar cost savings has been reported by the wellness program at the Phoenix FD, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.²⁸ NIOSH applauds the FD for working with the local union to develop the enhancements to the mandatory fitness/wellness program scheduled for implementation at the end of 2003.

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INVESTIGATOR INFORMATION

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